ΦΥΣΙΚΗ.— **Efficiency of the prediction of earthquakes from electrotelluric signals collected at distant stations,** *by S. Ginis - G. Avgoustis - A. Zisos - M. Lazaridou-Varotsou - E. Dologlou-Revelioti - P. Economopoulos - P. Karapanos and G. Giakoumakis**. Ἀνεκοινώθη ὑπὸ τοῦ Ἀκαδημαϊκοῦ κ. Καίσαρος Ἀλεξοπούλου.

Since a year ago all major eartquakes (EQ) in the area of Greece have been found to be preceded by transient changes of the telluric current (electrotelluric signals ES) [**1**]; their lead time is between 6 h and 9 hours. By operating stations at distances around 80 km from each other it was found that the ES appeared simultaneously at all stations. The epicenter of each EQ was known seismographically so that the amplitude[1] of the signals at each station could be compared to the corresponding epicentral distance r; they decrease according to a 1/r law with an accuracy within a factor of two. Assuming such a law as accurate, the epicenter of each EQ was computed from the electrotelluric data with an error usually within 50 and 100 km [**2**]. The magnitude of the earthquakes that occured during the above experiment happened to lie in the range between 3.2 and 5.1 R.

During the last months a wider network of stations was installed at distances betwen 150 and 300 km from each other. The present paper describes the preliminary results from the operation of such distant stations. They allow the evaluation of the efficiency of a network in function of the number of installed stations.

EXPERIMENTAL

A station at Glyfada (GLY) near Athens - see Fig. 1 - has been operating continuously for the past year [**1**]. At certain hours the signals

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* Σ. ΓΚΙΝΗ - Γ. ΑΥΓΟΥΣΤΗ - Α. ΖΗΣΟΥ - Μ. ΛΑΖΑΡΙΔΟΥ-ΒΑΡΩΤΣΟΥ - Ε. ΔΟΛΟΓΛΟΥ-ΡΕΒΕΛΙΩΤΗ - Π. ΟΙΚΟΝΟΜΟΠΟΥΛΟΥ - Π. ΚΑΡΑΠΑΝΟΥ - Γ. ΓΙΑΚΟΥΜΑΚΗ, **Ἀποτελεσματικότης ἐκτεταμένου δικτύου σταθμῶν προβλέψεως σεισμῶν.**

1. $I \equiv \frac{\Delta V}{R}$.

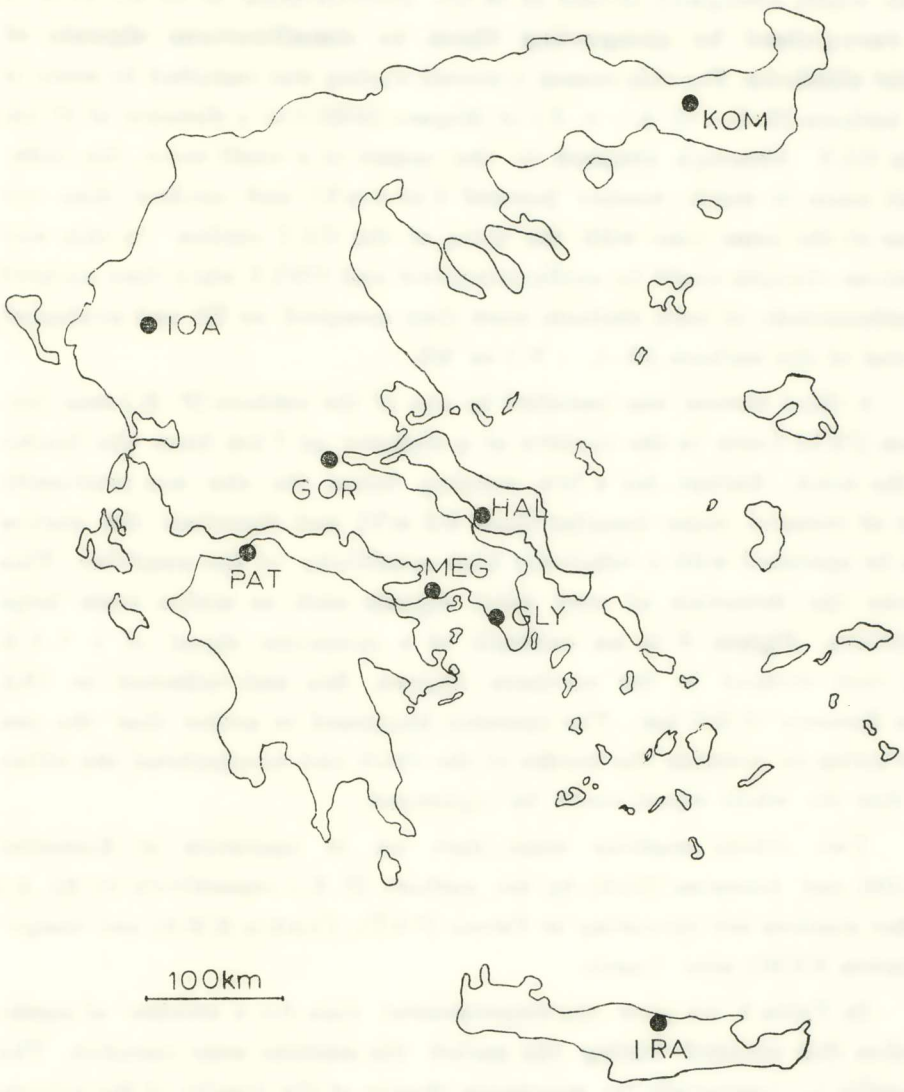

Fig. 1. Network of electrotelluric stations.

are disturbed by strong cultural noise (up to 10 mV on a 50 m line). Cases where ambiguity arrises as to the identification of an ES have to **be recognised by comparing them to simultaneous signals of other stations.** For this reason a second station was installed by some of the authors (S. G. ; G. A. ; A. Z.) at Megara (MEG) at a distance of 45 km from GLY. Although situated in the center of a small town, the industrial noise is much weaker (around 2 to 4 mV) and anyhow does not occur at the same time with the noise of the GLY station. In this way spurious changes could be easily compared and ONLY when they occured simultaneously at both stations were they accepted as ES and evaluated by one of the authors (M. L. - V.) as ES.

A third station was installed by one of the authors (P. E.) near Iraklion (IRA) Grete in the country at a distance of 7 km from the border of the town. Except for a few evening hours the site was practically free of cultural noise (smaller than 0.2 mV) and therefore the station can be operated with a relatively high sensitivity of the amplifier. This allows the detection of very weak signals such as arrive from large distances. Figure 2 is an example of a precursor signal of a 6.8 R EQ that occured in the northern Aegean. Sea and collected at IRA at a distance of 500 km. The operator happened to notice that the pen was going to override the border of the chart and manipulated the offset so that the whole signal could be registered.

Two others stations were then set in operation at Komotini (KOM) and Ioannina (IOA) by the authors (P. K.) repectively by (G. K.) Other stations are operating at Patras (PAT), Chalkis (CHA) and Gorgopotamos (GOR) near Lamia.

In Table I we give the experimental data for a number of earthquakes that occured during the period the stations were installed. The quantity j_{rel} represents the maximum change of the density of the telluric current in relative units after reduction of the data to lines of exactly 50 m length and after eliminating resistivity differences. The experimental errors of the values are around 30 to 50% and very seldom 100%.

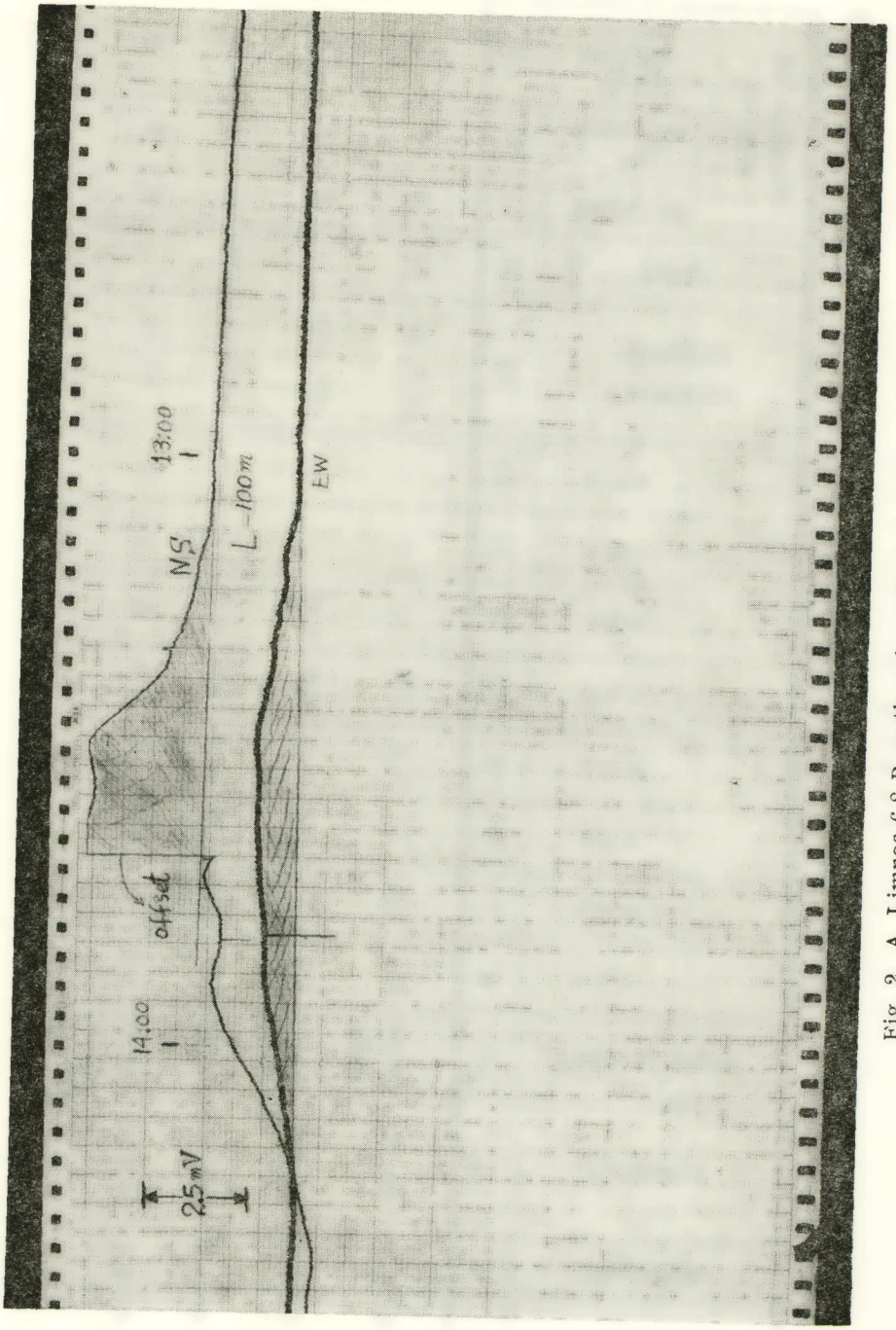

Fig. 2. A Limnos 6 8 R earthquake collected at IRA (500 km).

TABLE I.

Efficiency of network of stations. **(1982)**

Date	Time	Magnitude	Epicenter	Time of signal	j_{rel}								Calculated epicenter	Error km	Number of stations		
					GLY	MEG	IRA	KOM	PAT	IOA	CHA	GOR			Installed	In operation	With redable results
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
4/3	03: 03	4.3	−35; 75	18: 20 (3/3)	4.5	2.9	N	1.1	1.8	—	—	—	−128; 15	110	5	4	4
6/3	02: 16 (IV)	3.4	120 f.A.	19: 30 (5/3)	1.4	N 100%	∼0	n. 0.	0 9	0.85	—	—	−90; +80	—	6	5	3
23/3	21; 28	3.7	−105; 22	14: 53	3	4.4	0.38	n. 0.	2.3	n. 0.	—	—	−70; 18	36	6	4	4
24/3	04; 32	3.1	50 f.A.	19: 03 (23/3)	1.5	4	0.39	0.9	1.6	N	—	—	−41; 64	—	6	6	5

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
24/3	23; 54	4.0	−70; 35 * h: 90 km	17: 51	1.8	2.2	N	N	2	N	—	—	−120; 121	99	6	6	3
15/4	19; 25	** 3.8	−290; 180	10: 00	2.2	N	N	0.7	0 5	n. 0.	0.86	0.5	−143; 163	148	8	7	5
23/4	08; 35	4.2	−180 −40	00: 24	0.33	N	N	n. 0.	1.3	N	0.3	0.45	−183; −16	25	8	7	4

* h = focal depht (USCGS).

** from RLS, VLS and JAN (IOA) Observatory stations.

N = no measurement possible due to noise, f. A. = distance from Athens, n. 0. = station not in order Coordinates of epicenters in km relative to Athens.

The epicenters of the fourth column have been calculated by considering the recordings of the network of the National Observatory of Athens and the telemetric network of the following stations: ADM (Milos), VLN (SW of Peloponnese) and RDP (NW of Crete).

DETERMINATION OF EPICENTERS

By accepting a 1/r - law and usig the values of j_{rel} for each pair (i , k) of stations the epicenter of each EQ is determined by a computer minimisation procedure according to

$$\Sigma_{ik} (j_i r_i - j_k r_k)^2 = \min$$

where r_i and r_k are the unknown epicentral distances. The epicentral distance r_i of each station is expressed in terms of the known coordinates x_i , y_i of each station and the unknown coordinates x_0 , y_0 of the epicenter. The coordinates x_0 , y_0 calculated in this way are given in column 14; they can be compared to the seismographically determined ones in column 4. They are given in km in the sequence WE and SN, the origin being arbitrarily selected to be in Athens. In column 15 we give the errors Δr. The stations GLY and MEG due to their proximity must be considered as being a single station — at least — for remote EQ.

For some EQ the exact location of the epicenter was not available. It could only be expressed by the distance from Athens.

RELIABILITY OF STATIONS

In order to evaluate the importance of the number of installed stations we first compare column 16 with column 17. We notice that usually some of the installed stations are out of working order, as a result of thunderbolts that deteriorated the amplifiers (labelled with n. o. in the table). Cases where a measurement could not be made due to intense noise are labelled with N.

By increasing the number of stations a more accurate determination of epicenters could be achieved, although the present errors already seem to be acceptable for the description of an endangered area in a case of an impending EQ larger than 6 R.

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the computer calculations. On this occasion we must express our thanks to the officers and ranks of the army for their meticulous continuous measurement of the signals at the Patras, Ioannina, Chalkis and Gorgopotamos station.

ΠΕΡΙΛΗΨΙΣ

Κατὰ τὸ παρελθὸν ἔτος ἀνευρέθη ὅτι δίκτυον σταθμῶν καταμετρήσεως γεωρευμάτων εἶναι δυνατὸν νὰ προσδιορίση τὰ στοιχεῖα σεισμοῦ περίπου $7\,^1/_2$ ὥρας πρὸ τῆς ἐπελεύσεώς του. Ἡ ἀπόστασις μεταξὺ τῶν σταθμῶν ἦτο τῆς τάξεως τῶν 80 χιλιομέτρων, τὰ δὲ ἐπίκεντρα τῶν σεισμῶν ἐπεσημαίνοντο μὲ σφάλμα μεταξὺ 50 καὶ 100 km. Αἱ παροῦσαι μετρήσεις ἐγένοντο μὲ ἀραιότερον δίκτυον. Οἱ σταθμοὶ ἦσαν ἐγκατεστημένοι εἰς Γλυφάδα Ἀττικῆς, Μέγαρα, Ἡράκλειον Κρήτης, Κομοτινήν, Πάτρας, Ἰωάννινα, Χαλκίδα καὶ Γοργοπόταμον, δηλ. εἰς ἀποστάσεις τῆς τάξεως τῶν 150 ἕως 300 χιλιομέτρων. Εἰς πίνακα περιγράφονται τὰ σήματα καὶ τὰ δι' αὐτῶν προσδιοριζόμενα ἐπίκεντρα διὰ σεισμοὺς μεταξὺ 3 καὶ $4\,^1/_2$ R. Τὰ σφάλματα τῶν ἐπικέντρων εἶναι μικρότερα τῶν 150 χιλιομέτρων ὅταν τὰ σήματα προκύπτουν ἀπὸ 6 σταθμούς.

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